

**The  
Patent  
Office**

CARDIFF ROAD  
NEWPORT  
GWENT NP9 1RH

13 NOVEMBER 1991

PATENTS ACT 1977

**CONDITIONAL PERMIT FOR FILING A PATENT APPLICATION  
OUTSIDE THE UNITED KINGDOM**

Application No. 9103401.7

Filed 19 FEBRUARY 1991

On 1 MARCH 1991 directions were given under Section 22(1) prohibiting publication of information contained in the above-numbered application for defence reasons. The directions are still in force, but the applicant(s) is/are hereby authorised to apply in **THE UNITED STATES OF AMERICA** for grant of a patent in respect of matter contained in the application, subject to the conditions set forth below:-

- (1) The application has been classified by a defence authority of the United Kingdom as **RESTRICTED** and the receiving Government shall be requested to place the corresponding application in secrecy and accord it at least the equivalent security classification.
- (2) The corresponding application shall be abandoned if this action becomes necessary to ensure secrecy.
- (3) All correspondence relating to the corresponding application shall be transmitted solely through officially recognised adequately secure communication channels. All persons in the receiving country required to deal with the patent application there shall have been authorized to have access to such security classified information and be able to provide adequate physical security.
- (4) The applicant(s) shall make available to the receiving Government for defence purposes a copy of the application filed in that country.

This permit applies only to matter disclosed in the United Kingdom application, and it does not authorise the making of an application under the European Patent Convention or the Patent Cooperation Treaty.

*R. Kennell*

for the Comptroller

DP Per 3/77

The  
**Patent  
Office**

**CARDIFF ROAD  
NEWPORT  
GWENT  
NP9 1RH**

**RECEIVED  
OCT 27 1993  
LICENSING & REVIEW**

I, the undersigned, being an officer duly authorised in accordance with Section 62(3) of the Patents and Designs Act 1907, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of documents as originally filed in connection with the patent application identified therein.

I further certify that pursuant to Section 22(1) of the Patents Act, 1977, the Comptroller has ordered prohibition of publication of the said specification.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents, has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or the inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., P.L.C. or PLC.

Registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules:

Witness my hand this

13<sup>th</sup>

day of

SEPTEMBER 1993

*R. S. Viddell*

COC6 (SSA)

For official use

THE PATENT OFFICE

19 FEB 1991

RECEIVED BY POST

BRITISH RESTRICTED

DECLASSIFIED BY ORIGINATING AGENCY

19 FEB 1991

19FEB '91 H002A0666

PAT 1 77 UC

15.00

DETACHED FROM

Your reference

N.C. NO. 111/90

9103401.7

### Notes

Please type, or write in dark ink using CAPITAL letters. A prescribed fee is payable for a request for grant of a patent. For details, please contact the Patent Office (telephone 071-829 6910).

Rule 16 of the Patents Rules 1990 is the main rule governing the completion and filing of this form.

② Do not give trading styles, for example, 'Trading as XYZ company', nationality or former names, for example, 'formerly (known as) ABC Ltd' as these are not required.

### Warning

After an application for a Patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977 and will inform the applicant if such prohibition or restriction is necessary. Applicants resident in the United Kingdom are also reminded that under Section 23, applications may not be filed abroad without written permission unless an application has been filed not less than 6 weeks previously in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction revoked.

The  
Patent  
Office

## Request for grant of a Patent

Form 1/77

Patents Act 1977

### ① Title of invention

- 1 Please give the title of the invention EXHAUST NOZZLE FOR THRUST VECTORING.

### ② Applicant's details

#### ☐ First or only applicant

- 2a If you are applying as a corporate body please give:

Corporate name ROLLS-ROYCE plc

Country (and State of incorporation, if appropriate) ENGLAND

- 2b If you are applying as an individual or one of a partnership please give in full:

Surname

Forenames

- 2c In all cases, please give the following details:

Address 65 Buckingham Gate, London SW1E 6AT, England

UK postcode (if applicable) SW1E 6AT

Country ENGLAND

ADP number (if known)

BRITISH RESTRICTED

2d, 2e and 2f: If there are further applicants please provide details on a separate sheet of paper.

☐ **Second applicant (if any)**

2d If you are applying as an corporate body please give:  
Corporate name

Country (and State  
of incorporation, if  
appropriate)

2e If you are applying as an individual or one of a partnership please give in full:

Surname

Forenames

2f **In all cases**, please give the following details:

Address

UK postcode  
(if applicable)

Country

ADP number  
(if known)

③ An address for service in the  
United Kingdom must be supplied

Please mark correct box

**③ Address for service details**

3a Have you appointed an agent to deal with your application?

Yes ☒ No ☐ → go to 3b

↓  
please give details below

Agent's name M. A. GUNN

Agent's address P.O. Box 31, Moor Lane, Derby  
DE2 8BJ.

Postcode DE2 8BJ

Agent's ADP  
number

3b: If you have appointed an agent, all  
correspondence concerning your  
application will be sent to the agent's  
United Kingdom address.

3b If you have not appointed an agent please give a name and address in the  
United Kingdom to which all correspondence will be sent:

Name

Address

Postcode

ADP number  
(if known)

Daytime telephone  
number (if available)

DECLASSIFIED  
BRITISH RESTRICTED

**BRITISH RESTRICTED**

- ⑦ The answer must be 'No' if:
- any applicant is not an inventor
  - there is an inventor who is not an applicant, or
  - any applicant is a corporate body.

⑧ Please supply duplicates of claim(s), abstract, description and drawing(s).

Please mark correct box(es)

⑨ You or your appointed agent (see Rule 90 of the Patents Rules 1990) must sign this request.

Please sign here →

A completed fee sheet should preferably accompany the fee.

7 Are you (the applicant or applicants) the sole inventor or the joint inventor?

Please mark correct box

Yes ☐

No ☒

A Statement of Inventorship on Patents Form 7/77 will need to be filed (see Rule 15).

### ⑧ Checklist

8a Please fill in the number of sheets for each of the following types of document contained in this application.

Continuation sheets for this Patents Form 1/77

Claim(s)

2

Description

6

Abstract

1

Drawing(s)

2 ✓

8b Which of the following documents also accompanies the application?

Priority documents (please state how many)

Translation(s) of Priority documents (please state how many)

Patents Form 7/77 – Statement of Inventorship and Right to Grant (please state how many)

☒

Patents Form 9/77 – Preliminary Examination/Search

☒

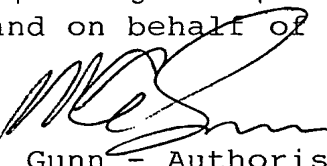
Patents Form 10/77 – Request for Substantive Examination

☒

### ⑨ Request

I/We request the grant of a patent on the basis of this application.  
For and on behalf of ROLLS-ROYCE plc

Signed



Date 18 2 91.  
(day month year)

M. A. Gunn – Authorised by Power of Attorney

**Please return the completed form, attachments and duplicates where requested, together with the prescribed fee to:**

☐ **The Comptroller  
The Patent Office  
State House  
66–71 High Holborn  
London  
WC1R 4TP**

BRITISH RESTRICTED

BRITISH RESTRICTED

**BRITISH RESTRICTED**  
DECLASSIFIED BY ORIGINATING AGENCY

### ⑤ Claiming an earlier application date

Please mark correct box



***please give details below***

 filing date

(day      month      year)

Please mark correct box

15(4) (Divisional) ☐ 8(3) ☐ 12(6) ☐ 37(4) ☐

### ⑥ Declaration of priority

6 If you are declaring priority from previous application(s), please give:

*Please give the date in all number format, for example, 31/05/90 for 31 May 1990.*

Country of filing

Priority application number  
(if known)

Filing date  
(day, month, year)

RECEIVED

**BRITISH RESTRICTED** BY ORIGINATING AGENCY

For official use

THE PATENT OFFICE

19 FEB 1991

RECEIVED BY POST

BRITISH RESTRICTED

19 FEB 1991

Your reference

N.C. NO. 111/90

9103401.7

**Notes**

Please type, or write in dark ink using CAPITAL letters.

No fee is required with this form.

Rule 15 of the Patents Rules 1990 is the main rule governing the completion and filing of this form.

If you do not have enough space please use a separate sheet of paper.

When an application does not declare priority at all, or declares priority from an earlier UK application, sufficient additional copies of this form must be supplied to enable the Comptroller to send one to each inventor who is not an applicant.

The  
Patent  
Office

**Statement of inventorship and  
of right to grant of a Patent**

**Form 7/77**

**Patents Act 1977**

**① Application details**

1a Please give the patent application number (if known):

1b Please give the full name(s) of the applicant(s):

ROLLS-ROYCE plc

65 Buckingham Gate, London SW1E 6AT, England.

**② Title of invention**

2 Please give the title of the invention:

EXHAUST NOZZLE FOR THRUST VECTORING

**③ Derivation of right**

3 Please state how the applicant(s) derive(s) the right to be granted a patent:

By virtue of Assignment dated: 15 February 1991

**④ Declaration**

4 I believe the person(s) named overleaf (and on any supplementary copies of this form) to be the inventor(s) of the invention for which the patent application has been made. I consent to the disclosure of the details contained in this form to each inventor named.

For and on behalf of Rolls-Royce plc

Signed



Date

18 2 91.  
(day month year)

M. A. Gunn - Authorised, by Power of Attorney

Please sign here ➡

Please turn over ➡

BRITISH RESTRICTED

**BRITISH RESTRICTED**

Please put the full name(s) and address(es) of the inventors in the boxes below:

Please underline the surnames or family names.

LEONARD JOHN RODGERS  
6 Coniston Avenue  
Spondon  
DERBY.

ADP number (if known):

ADP number (if known):

Please give the names of any further inventors on the back of another form 7/77 and attach it to this form.

**Reminder**

Have you signed the declaration  
overleaf?

ADP number (if known):

**BRITISH RESTRICTED**



ORIGINATING AGENCY  
**BRITISH RESTRICTED**  
DECLASSIFIED BY

ROLLS-ROYCE plc

CASE NO.

SHORT TITLE: "TORSIONALLY FLEXIBLE NOZZLE FLAP"

APPLICATION NO.

DATED:

FIRST APPLICATION

DRAFTED BY: RAB

PATENTS ACT 1977

SPECIFICATION

EXHAUST NOZZLE FOR THRUST VECTORING

ORIGINATING AGENCY  
**BRITISH RESTRICTED**  
DECLASSIFIED BY

BRITISH RECYCLED



BRITISH RECYCLED

BRITISH RESTRICTED

DUPLICATE

### EXHAUST NOZZLE FOR THRUST VECTORING

The present invention relates to an exhaust nozzle for a gas turbine engine and in particular to an exhaust nozzle capable of vectoring a flow of exhaust gases issuing therefrom at an angle to the centre line of the engine.

Military aircraft often need to have a high rate of turn in situations where the aircraft control surfaces are inadequate. For this purpose it is desirable for the engine to be provided with a propulsion nozzle which can deflect the exhaust gases to give a thrust at an angle to the centre line of the engine.

A conventional exhaust nozzle for thrust vectoring comprises a convergent and divergent section. The convergent section of the nozzle defines at its downstream end a nozzle throat of variable diameter. The exhaust gases are accelerated through the nozzle throat to the divergent section which contains the high pressure gas generated by the accelerated exhaust gases. The divergent portion defines at its downstream end a nozzle exit. The convergent and divergent sections of the nozzle comprise a plurality of radially outer and radially inner flaps which are circumferentially disposed around the engine. The plurality of flaps are substantially rectangular and rigid and define a flow path through which the exhaust gases flow. The flow path for the exhaust gases is defined by the outer and inner flaps alternately overlapping each other. The outer flaps in the convergent and divergent section of the nozzle are actuated positively to vary the nozzle throat and exit respectively. The inner flaps stay in contact with the outer flaps due to the outward gas pressure of the exhaust gases when the engine is operational. When the engine is not operational the inner flaps are kept in contact with the outer flaps by flexible spring retainers or other similar devices.

Actuation of the outer flaps may be provided by a number of actuators which act on the outer flaps either independently or via a unison ring. The actuators can act

BRITISH RESTRICTED

DECLASSIFIED BY ORIGINAL ISSUING AGENCY  
**BRITISH RESTRICTED**

2

directly on the outer flaps or through an outer fairing. To obtain deflected thrust the outer flaps of the divergent section of the nozzle are actuated so as to move them asymmetrically with respect to the engine centre line. The outer flaps are moved differentially so that the outer flaps on one side of the nozzle move to a different angle to the outer flaps on the other side. In this way the thrust line can be moved up or down or side to side to control the pitch and yaw axis.

A problem with conventional convergent/divergent nozzles is that when the outer flaps in the divergent section are moved asymmetrically to take up different angles, the inner flaps are unable to stay in contact with adjacent outer flaps. The inner flaps are therefore unable to seal against the outer flaps and leakage of the exhaust gases can occur.

The present invention seeks to provide an exhaust nozzle in which the inner flaps remain in sealing contact with the outer flaps when the outer flaps are moved asymmetrically.

According to the present invention an exhaust nozzle for a gas turbine engine capable of vectoring a flow of exhaust gases issuing therefrom at an angle to the centre line of the engine, the exhaust nozzle comprises a plurality of radially outer and radially inner flaps circumferentially disposed around the engine, the radially outer and radially inner flaps alternately overlap each other to define a flow path through which the exhaust gases flow, the radially outer flaps being provided with means for moving the flaps asymmetrically about the engine centre line, the radially inner flaps being urged into sealing contact with the radially outer flaps by the exhaust gas flowing through the nozzle, the radially inner flaps being torsionally flexible along their length so as to allow them to twist so as to maintain sealing contact with the radially outer flaps when the radially outer flaps are moved asymmetrically.

Preferably each of the radially inner flaps is divided

DECLASSIFIED BY ORIGINAL ISSUING AGENCY  
**BRITISH RESTRICTED**

into a plurality of triangular sections so it is torsionally flexible along its length. The triangular sections of the radially inner flaps may be interconnected by hinges.

The radially outer flaps are preferably moved asymmetrically with respect to the engine centre line by linear actuators pivotally connected to the radially outer flaps. The radially outer flaps may be moved asymmetrically with respect to the engine centre line by linear actuators which are connected to the flaps by an unison ring. In one embodiment of the present invention each of the radially outer and radially inner flaps has a convergent and divergent section. The convergent and divergent portions of the radially outer and radially inner flaps may be joined together by hinges.

The nozzle may be provided with an outer fairing.

The present invention will now be described by way of example and with reference to the accompanying drawings in which,

Figure 1 is a partially cut away pictorial view of an exhaust nozzle in accordance with the present invention.

Figure 2 is a rear view of the nozzle in figure 1.

Figure 3 is a radial view along arrow A in figure 2 of one of the radially inner flaps of the nozzle.

Referring to figure 1 an exhaust nozzle, generally indicated at 10, is in series flow relationship with a fixed area duct 9. The exhaust nozzle 10 comprises a convergent section 14 and a divergent section 20. The convergent section 14 and the divergent section 20 are each formed from a plurality radially outer flaps, 16 and 25 respectively, and inner flaps, 18 and 26 respectively, which are circumferentially disposed around the engine. The outer 16 and inner flaps 18 of the convergent section 14 define at their downstream ends a throat 19 the area of which can be varied. The outer 25 and inner 26 flaps of the divergent section 20 define at their downstream ends an exit 27 of the nozzle 10 through which the engine efflux flows. The outer flaps 25 and inner flaps 26 of the

divergent section 20 can move asymmetrically with respect to the engine centre line 8 to deflect the engine efflux issuing therefrom at an angle to the engine centre line 8.

The radially outer 16 and inner flaps 18 of the convergent section 14 are substantially rectangular and by overlapping alternate outer 16 and inner flaps 18 a complete cone is formed. The downstream ends of the outer 16 and inner flaps 18 in the convergent section 14 define the nozzle throat 19. The outer flaps 16 of the convergent section 14 are actuated positively to vary the diameter of the throat 19. The outer flaps 16 are actuated by linear actuators 11 which are connected to a unison ring 13. The linear actuators 11 are equally spaced around the fixed area duct 9 and may be hydraulic or pneumatic. When activated the linear actuators 11 cause rods 12 to translate the unison ring 13. The unison ring 13 translates to move a roller 14 along a cam 15 which causes the outer flaps 16 to pivot changing the area of the nozzle throat 19.

Although pivoting of the outer flaps 16 to control the area of the nozzle throat 19 has been described by way of the unison ring 13 moving a roller 14 along a cam 15 it will be appreciated that any mechanisms which are well known in the art could be used for this purpose.

The inner flaps 18 of the convergent section 14 are not actuated positively but stay in contact with the outer flaps 16 because of the outward pressure of the exhaust gases flowing through the nozzle 10. When the engine is not operational the inner flaps 18 are kept in contact with the outer flaps 16 by flexible spring retainers 30 or other similar devices. The width and number of inner flaps 18 used is chosen to give sufficient overlap without the edges meeting at the minimum throat area or separating too far to make a gap for the exhaust flow to escape.

The exhaust gases are accelerated through the throat area 19 and pass through the divergent section 20. The divergent section 20 is configured in the same way as the convergent section 14, there being a plurality of radially outer 25 and inner flaps 26 circumferentially disposed

BRITISH RESTRICTED

around the engine. The outer 25 and inner flaps 26 of the divergent section 20 are hinged from the ends of the outer 16 and inner flaps 18 respectively of the convergent section 14. The outer flaps 25 of the divergent section 20 are positively actuated. The inner flaps 26 are maintained in sealing contact with the outer flaps 25 by the outward pressure of the exhaust gases passing therethrough. The outer flaps 25 of the divergent section 20 are actuated by a number of linear actuators 21 which are connected to a unison ring 22. The linear actuators 21 may be pneumatic or hydraulic and move the unison ring 22 via rods 23 further on one side than the other. The unison ring 22 is translated and tilts to move fairing 24 which pivots the outer flaps 25 of the divergent section 20. The outer flaps 25 are actuated so that the outer flaps 25 on one side of the divergent section 20 are moved to a different angle than those on the other side of the divergent section 20. In this way the direction of the exhaust gases issuing from the nozzle exit 27 can be moved up or down to control the associated aircraft (not shown) in the pitch axis or moved from side to side to control the aircraft in the yaw axis or any combination thereof.

As each of the outer flaps 25 of the divergent section 20 takes up a different angle the inner flaps 26 remain in sealing contact, figure 2, by twisting along their lengths. The inner flaps 26 are torsionally flexible along their lengths and this allows the inner flaps 26 to twist along their lengths until they are in sealing contact with adjacent outer flaps 25 which are at different angles. The inner flaps 26 are stiff across their width so that they can withstand the pressure applied on them by the exhaust gases passing therethrough.

The inner flaps 26 are made torsionally flexible by their division into triangular portions 29 interconnected by a series of angled hinges. The hinge axes are indicated by the broken lines 28 in figure 3. The angled hinges may be one piece springs as each hinge has only to move through a small angle. The triangular portions 29 are alternated to

BRITISH RESTRICTED

BRITISH RESTRICTED

6

give the inner flap 26 its rectangular shape. Each triangular portion 29 has its own retainer 30 to keep it in contact with the outer flaps 25 when there are no exhaust gases flowing therethrough. The retainer 30 may be a spring or some other similar device.

It will be appreciated that although the arrangement described uses actuators on the outer flaps 16 and 25 of the convergent 14 and divergent 20 sections respectively to operate them independently of one another it would be less complicated to link the convergent 14 and divergent section 20 together so they are operated by the same actuators. Alternatively the outer flaps 25 of the divergent section 20 could move freely in response to the pressure loads acting on them.

Although the present invention has been described with reference to a convergent/divergent nozzle it will be appreciated by one skilled in the art that it is equally applicable to any nozzle where a number of radially outer and inner flaps are used and which need to be maintained in sealing contact. For example the invention could be used in propulsion nozzles which only has a single section each of the outer and inner flaps in this section being convergent at their upstream ends and divergent at their downstream ends.

BRITISH RESTRICTED



DECLASSIFIED  
BRITISH  
RESTRICTED  
ORIGINATING AGENCY

DECLASSIFIED BY ~~BRITISH~~ ~~RESTRICTED~~ ORIGINATING AGENCY

8

8. An exhaust nozzle as claimed in any preceding claim in which the nozzle is provided with an outer fairing.

9. An exhaust nozzle as hereinbefore described by way of example and as shown in the accompanying drawings.

DECLASSIFIED BY ~~BRITISH~~ ~~RESTRICTED~~ ORIGINATING AGENCY

ABSTRACT

EXHAUST NOZZLE FOR THRUST VECTORING

An exhaust nozzle (10) for a gas turbine engine is described for vectoring a flow of exhaust gases issuing therefrom at an angle to a centre line (8) of the engine. The exhaust nozzle (10) comprises a plurality of radially outer (25) and radially inner flaps (26) which are circumferentially disposed around the engine. The radially outer (25) and radially inner flaps (26) alternately overlap each other to define a path through which the exhaust gases flow. The radially outer flaps (25) can be moved asymmetrically about the engine centre line (8). The radially inner flaps (26) are maintained in sealing contact with the outer flaps (25) by the flow of exhaust gases passing therethrough. The radially inner flaps (26) are divided into a number of triangular sections (29) which renders the flaps (26) torsionally flexible so that they can twist along their lengths to maintain sealing contact with adjacent radially outer flaps (25) when the outer flaps (26) are moved asymmetrically.

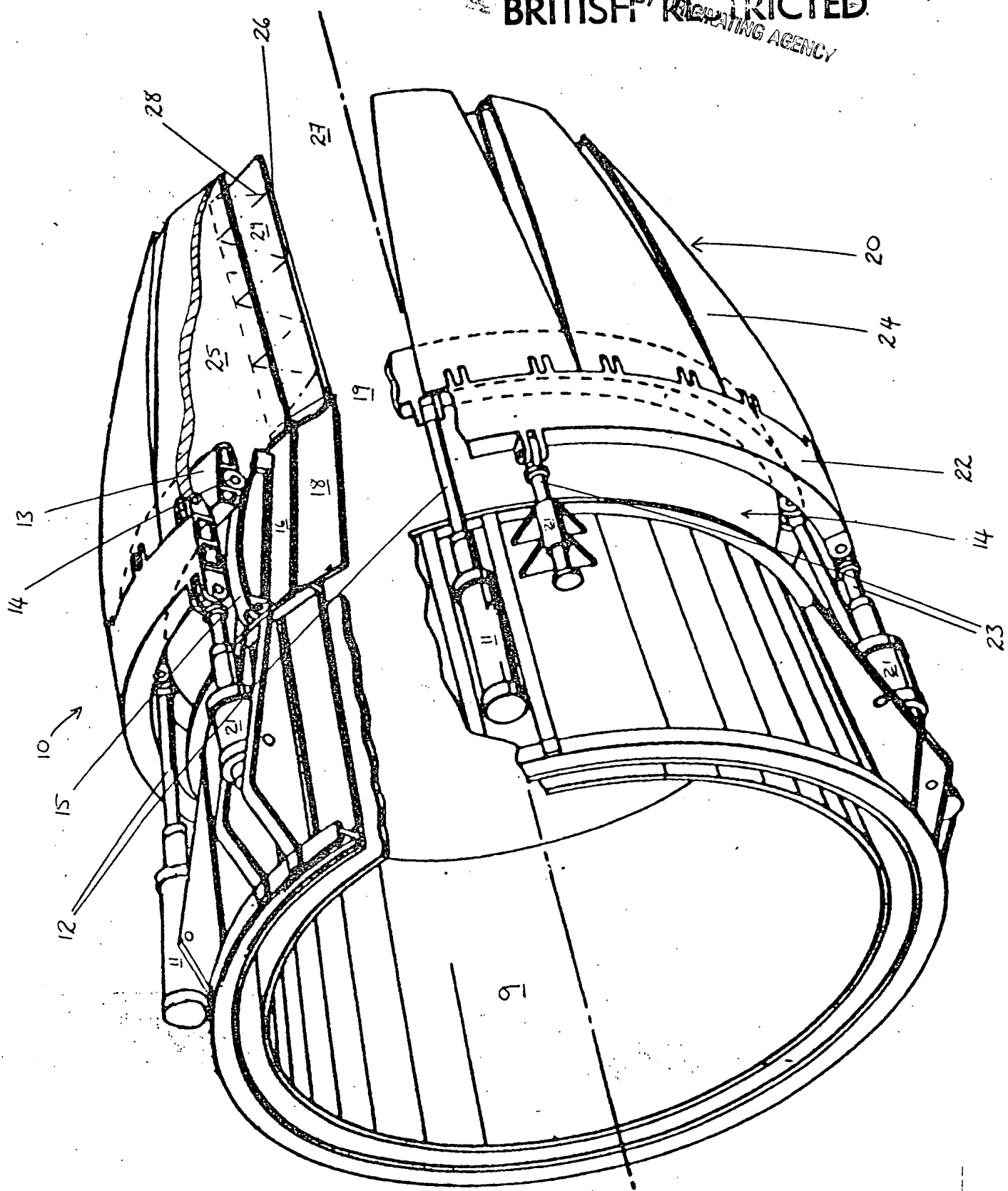


Figure 1.

Figure 2.

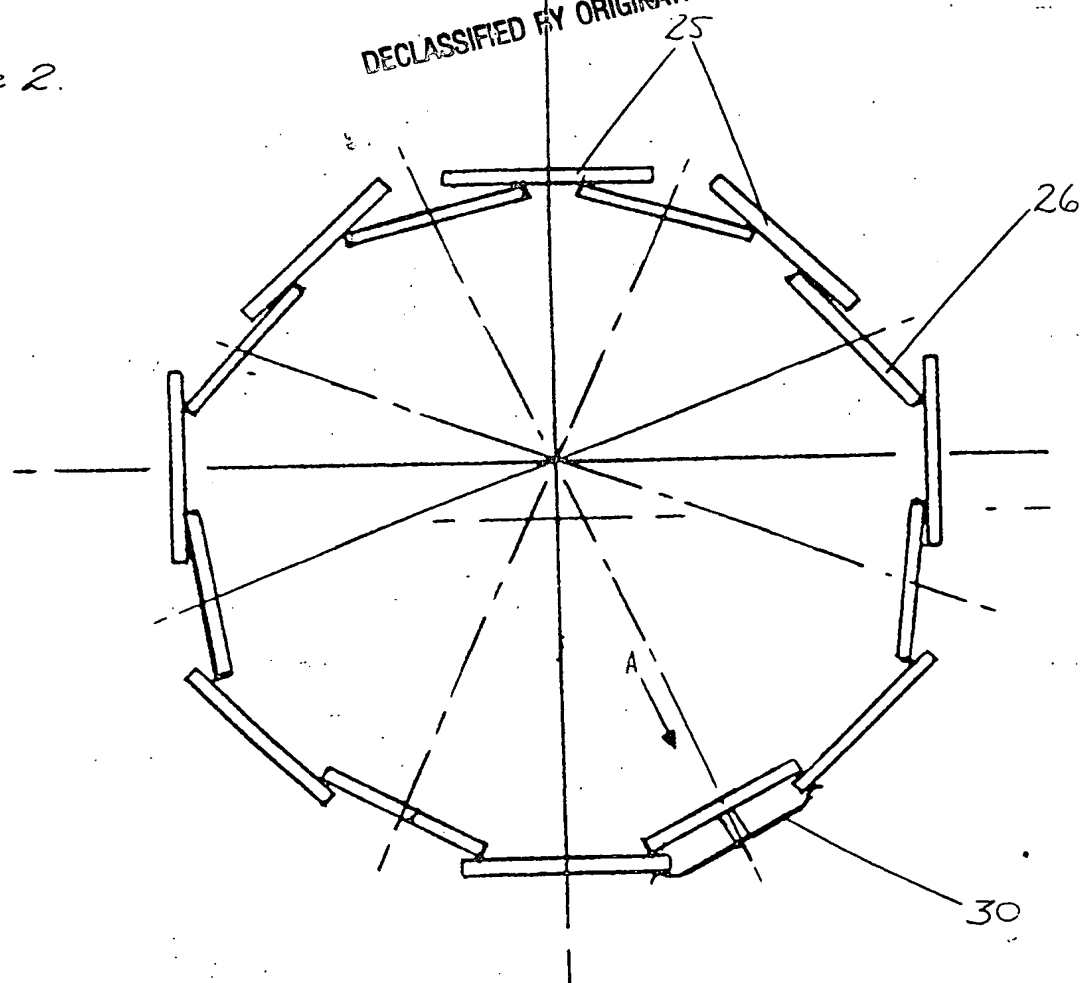


Figure 3.

